

## **WIRELESS NETWORK SYSTEM AND COMMUNICATIONS METHOD**

### **CROSS-REFERENCE TO RELATED APPLICATIONS**

[001] The present application claims priority under 35 U.S.C. 119, based on Japanese patent application No. 2002-275651, filed September 20, 2002.

### **BACKGROUND OF THE INVENTION**

#### **1. Field of the Invention**

[002] The present invention relates to a wireless network system, and a wireless communications method using the described network. More particularly, the present invention relates to a wireless network system and a wireless communications method suitable for a vehicle intercom performing short-range communications, utilizing an ISM (Industry Science Medical) band.

#### **2. Description of the Relevant Art**

[003] BLUETOOTH® is a registered trademark of the Bluetooth Special Interest Group (Bluetooth SIG), an industry consortium dedicated to setting standards for wireless radio communication. The Bluetooth SIG has published a specification relating to short distance radio communication between electronic devices, in the 2.4 GHz band. The Bluetooth® specification is accessible via [www.bluetooth.com](http://www.bluetooth.com), and the disclosure of the Bluetooth® specification is incorporated herein by reference. More information about Bluetooth® can be found at [www.bluetooth.com](http://www.bluetooth.com). As used herein, the term "Bluetooth®", when used in relation to an electronic device, is intended to mean that the device functions in compliance with the Bluetooth® specification.

[004] For allowing two-wheel vehicle occupants to talk to each other, it has been known

to provide each of the occupants helmets with a headset, including a speaker, a microphone, and a portable wireless terminal. Such a communications system (intercom) is exemplarily disclosed in JP-UM-A-62-155535.

[005] Similarly, JP-A-2001-148657 discloses a wireless terminal mounted on the side of a vehicle, for relaying conversations made by occupants on the same or different vehicle(s) using headsets. In the technology discussed in JP-A-2001-148657, the Bluetooth® specification is adopted as a wireless communications standard for intercoms.

[006] Although the known devices have some utility for their intended purposes, a need still exists in the art for an improved wireless network system and wireless communications method for use in connection with vehicles. In particular, there is a need for an improved ability for wireless communication between vehicle occupants.

#### SUMMARY OF THE INVENTION

[007] The present invention provides an apparatus for use in wireless communications. Bluetooth® is one of the short-range wireless communications standard utilizing an ISM band of 2.4 GHz, and is used mainly for establishing connection between a personal computer and peripheral equipment such as a printer, a modem, or a keyboard, or between a mobile phone and a personal computer. Using Bluetooth® eliminates the need for a cable for device connection, thereby considerably improving the device usability. Bluetooth® is classified into three classes in terms of transmission output. Specifically, class 1 is 100 milliwatts at the maximum (maximum transmission distance 100m), class 2 is 2.5 milliwatts at the maximum, and class 3 is 1 milliwatt at the maximum (maximum transmission distance 10m).

[008] Devices compatible with the Bluetooth® specification can be characterized as either a master, determining a frequency hopping pattern, or as a slave, following the pattern set by the master. Seven slaves, at the maximum, can be grouped together with a master. Such a master and slaves structure a wireless network, which is called a piconet.

A master in one piconet can be a slave in another piconet at the same time. Utilizing such a feature, a technology has been proposed to connect multiple piconets together in a string, to construct a wireless network system much larger in size. The resulting network is called a scatternet, which is yet in the design phase.

[009] Next, referring to FIGS. 6 and 7, four occupants on two vehicles A and B will be discussed, in relation to their communications with one another using an intercom.

[010] A helmet, for an occupant to wear, is provided with a microphone 1, a speaker 2, and a portable wireless terminal 3, of radio frequency type. A relay device 4 is mounted on each of first and second vehicles A and B, respectively, for enabling wireless communications between the portable wireless terminals 3.

[011] The portable wireless terminal 3 is of a battery-operated type, while the relay device 4 receives electricity from a storage battery 5, which is mounted on the vehicle.

[012] In such a system structure, for the occupants on the same vehicle, i.e., driver and passenger, to communicate with each other, in a first arrangement shown in FIG. 6, the driver's voice is detected by the microphone 1, converted into an audio signal, and then transferred to the portable wireless terminal 3 over a helmet-mounted cable. A driver's terminal 3ad communicates with a passenger's terminal 3ap via a relay device 4a, provided on the same vehicle.

[013] Furthermore, in the arrangement of Figure 6, when the occupants on different vehicles wish to communicate with each other, for example, a radio wave, sent out from the driver's terminal 3ad of the first vehicle A, is initially received by the relay device 4a of the same vehicle. Then, the radio wave is relayed and is sent out again. The radio wave sent out from the relay device 4a is received by the passenger's terminal 3ap on the first vehicle A, and received simultaneously by a driver's terminal 3bd and a passenger's terminal 3bp both belonging to the second vehicle B.

[014] Another radio wave, sent out from the driver's terminal 3bd of the second vehicle

B, is received by the relay device 4b of the same vehicle, is amplified therein and sent out again. The radio wave sent out from the relay device 4b is received by the passenger's terminal 3bp on the second vehicle B, and is received simultaneously by the driver's terminal 3ad and the passenger's terminal 3ap of the first vehicle A.

[015] In a second arrangement of the components, as shown in FIG. 7, the occupants on the same vehicle communicate in the same manner as in the above first arrangement, but the occupants on the first vehicle A and the occupants on the second vehicle B communicate only via the respective relay devices 4a and 4b. This is different from the above first arrangement, as will be made clear by a comparison of Figure 6 with Figure 7.

[016] When attaching a portable wireless terminal 3 to an occupant's helmet, if power is to be supplied from the corresponding vehicle, appropriate power supply wiring is needed to provide a hard-wired connection between the first vehicle and the occupant's helmet, which is inconvenient. In order to avoid the need for such power supply wiring, it is possible to provide power from a small portable battery inside of the wireless terminal 3. With this structure, however, a technology for minimizing electricity consumption by the wireless terminal 3 is needed, to enable longer battery operation for the small portable battery therein.

[017] For a Bluetooth<sup>®</sup> piconet, a power-saving mode called "Sniff Mode" is available. Within a piconet, slaves are allowed to shift into sniff mode, but a master device is not allowed to so shift. Therefore, whichever terminal is operating as master tends to consume battery power faster than the other terminals, operating as slaves.

[018] Once the master becomes inoperable due to weak battery, slaves in the same piconet also become inoperable, no matter how fresh their batteries are. In view thereof, in the intercom described in the above, it is preferable that the relay device 4, receiving power from the vehicle-mounted storage battery 5 be designated as the master, and the battery-operated helmet-mounted terminals 3, with more limited power resources, be

designated as slaves.

[019] Further, in the first communications arrangement shown in FIG. 6, when the occupants on the vehicles A and B want to talk to each other, a wireless terminal 3 attached to one occupant's helmet has to communicate with a relay device mounted on the other vehicle. This may become difficult if the vehicle-to-vehicle distance exceeds 10 meters, and thus requires the transmission electricity of class 1 (high power). This resultantly increases electricity consumption, whereby there is no choice but to include a battery of larger capacity.

[020] On the other hand, in the second communications arrangement of FIG. 7, the wireless terminals 3, each attached to the occupants' helmets, only need to communicate with the relay device 4 on the corresponding vehicle. Accordingly, transmission electricity of about class 2 or 3 (middle to low power) may be enough therefor. As such, this permits the use of a smaller battery size in the terminal 3, and extends battery life as compared to the arrangement of Figure 6.

[021] A concern here is that, in the second communications arrangement of Figure 7, three different piconets are created. A first piconet has to be structured containing the relay device 4a and the wireless terminals 3ad and 3ap, in the first vehicle A. A second piconet has to be structured containing the relay device 4a in the first vehicle A and the relay device 4b in the second vehicle B, and a third piconet has to be structured containing the relay device 4b and the wireless terminals 3bd and 3bp in the second vehicle B.

[022] The problem is that, in the network structured as above, e.g., if the relay device 4a in the first vehicle A is designated as a master, then the relay device 4b of the second vehicle B will become a slave. This may result in either the portable wireless terminal 3bd or 3bp being a master. Thus, it is difficult to minimize the consumption of electricity.

[023] Herein, structuring a scatternet by those three piconets may be a possibility, to allow the terminals 3 and 4 to operate with either one acting as master or slave. However,

the scatternet has not yet been completely defined by specifications, and still requires development time before it will be available for practical use. Even if the scatternet is currently constructable, one Bluetooth® module allows only, at maximum, three SCO (Synchronous Connection Oriented) links to be established therein for audio communications, thereby imposing added limitations.

[024] An object of the present invention is to solve the conventional problems described above, and without adopting the described scatternet, to provide a wireless network system and a wireless communications method enabling good communications, while minimizing the electricity consumption of a portable terminal.

[025] In order to achieve the above object, a wireless network system including a plurality of Bluetooth® terminals, according to an illustrative embodiment of the present invention is provided. The system, according to the first embodiment, includes a first relay device including first and second Bluetooth® modules. Each of the Bluetooth® modules performs cable communications irrespective of which is a master/slave. The system hereof also includes at least one first wireless terminal including a third Bluetooth® module; a second relay device including a fourth Bluetooth® module; and at least one second wireless terminal including a fifth Bluetooth® module.

[026] In the use of the system hereof, characteristically, the first and third Bluetooth® modules structure a first Piconet in which the first Bluetooth® module is a master and the third Bluetooth® module is a slave. The second, fourth, and fifth Bluetooth® modules structure a second Piconet in which the fourth Bluetooth® module is a master, and the second and fifth Bluetooth® modules are slaves.

[027] With the characteristics described above, the first relay device structures the first Piconet with the first wireless terminal using the first Bluetooth® module belonging thereto, and using the second Bluetooth® module, structures the second Piconet with the second relay device and the second wireless terminal. With such a structure, without adopting a

scatternet, the first relay device can operate as both a master and a slave. Further, as for the transmission electricity class, class 3 (low power) is adopted to the first Piconet, and class 1 (high power) is adopted to the second Piconet. As such, the relay devices can achieve long-distance communications therebetween, and the wireless terminals can minimize power consumption therein.

[028] Accordingly, it is an object of the present invention to provide a method and apparatus for facilitating wireless communications.

[029] For a more complete understanding of the present invention, the reader is referred to the following detailed description section, which should be read in conjunction with the accompanying drawings. Throughout the following detailed description and in the drawings, like numbers refer to like parts.

#### **BRIEF DESCRIPTION OF THE DRAWINGS**

[030] Figure 1 is a block diagram showing, in a wireless network system to which the present invention is applied, the structure of a relay device to be mounted on a first vehicle, in a communications system according to a first illustrative embodiment of the invention.

[031] Figure 2 is a block diagram showing, in the wireless network system to which the present invention is applied, the structure of a portable wireless terminal for an occupant, and also illustrating the structure of a relay device to be mounted on a second vehicle, in the communications system according to the first embodiment hereof.

[032] Figure 3 is a diagram schematically showing the structure of a wireless network according to the first embodiment of the present invention.

[033] Figure 4 is a diagram schematically showing the structure of a wireless network according to a second illustrative embodiment of the invention.

[034] Figure 5 is a diagram schematically showing the structure of a wireless network, according to a third illustrative embodiment of the invention.

[035] Figure 6 is a diagram showing a first arrangement of a voice intercom

communications system for two vehicles.

[036] Figure 7 is a diagram showing a second, alternative arrangement using the voice intercom communications system.

#### **DETAILED DESCRIPTION OF THE INVENTION**

[037] In the following description, a number of presently preferred embodiments of the present invention are described in detail by referring to accompanying drawings. In the present embodiment, as in the second arrangement described by referring to FIG. 7, a communications arrangement is adopted in which occupants on different vehicles talk to each other exclusively via the relay devices 4, on the corresponding vehicles, and occupants on the same vehicle talk to each other via the relay device 4 on their own vehicle.

[038] FIG. 1 is a block diagram, showing the structure of a relay device 4a to be mounted on a first vehicle A (Figure 7), in a wireless network communications system according to a first embodiment of the present invention.

[039] FIG. 2 is a block diagram showing a structure which represents the internal structure of each of the portable wireless terminals 3 (3ad, 3ap, 3bd, and 3bp) to be attached to occupants' helmets, respectively. The structure shown in Figure 2 also represents that of the relay device 4b to be mounted on the second vehicle B. Herein, only structures considered necessary for clarifying the present invention are described. Other conventional structures, and those of ancillary and auxiliary components of the system, are assumed to be known and understood by those skilled in the art.

[040] In the embodiment shown in FIG. 1, the relay device 4a, mounted on the first vehicle A, includes two BT modules. The Bluetooth® (hereafter denoted by BT) modules are characterized in being connected together over a cable via a bus, and perform communications with each other irrespective of which is a master or a slave. The BT modules are provided with antennas AT1 and AT2, respectively. The portable wireless terminals 3, attached to the occupants' helmets, and the relay device 4b, to be mounted on



the second vehicle B, are different from the relay device 4a mounted on the first vehicle A in that in these devices, as shown in FIG. 2, the BT module and the corresponding antenna AT are each singularly provided.

[041] A CPU 33 executes various processes in accordance with a program stored in ROM 34. In the relay device 4a in FIG. 1, one CPU 33 controls two BT modules. RAM 35 provides a work area for the CPU 33 to temporarily store data or the like, for example, at the time of executing various processes. Various operation switches and a display device are connected to an input/output interface 36. The two BT modules, the CPU 33, the ROM 34, the RAM 35, and the interface 36 are all connected to one another via a common bus.

[042] The BT modules are each structured mainly by an RF unit 31, and a BT chip 32. The BT chip 32 executes a process of establishing inter-piconet synchronization with another terminal, a process of encoding/decoding transmission/reception signals, and the like. In detail, each of the BT modules subjects a carrier signal to digital modulation using transmission data at the time of transmission, and the resulting modulated carrier signal is subjected to spread-spectrum utilizing frequency hopping.

[043] Then, after amplifying the transmission signal to be a transmission output level of a predetermined value or lower, the result is transmitted toward another wireless terminal from the antenna AT. Also, a radio signal coming from the wireless terminal belonging to the person who is currently communicating with is received via the antenna AT for subjecting the same to inverse-spread-spectrum, and then to digital demodulation.

#### First Embodiment

[044] FIG. 3 is a diagram schematically showing the structure of the first embodiment of the wireless network system according to the present invention. Therein, a first BT module ①, incorporated in the relay device 4a mounted on the first vehicle A, and two BT modules ② of the portable wireless terminals 3ad and 3ap, structure a first piconet 20.

The modules ③ are each attached to the occupants' helmets on the first vehicle A.

[045] In this first piconet 20, the first BT module ① operates as a master, and the third BT modules ③ operate as slaves. The transmission electricity selected therein is low powered electricity of level 3.

[046] Also in the embodiment of Figure 3, a second BT module ②, incorporated in the relay device 4a mounted on the first vehicle A, a fourth BT module ④, incorporated in the wireless terminal 4b of the second vehicle B, and fifth BT modules ⑤ of the portable wireless terminals 3bd and 3bp structure a second piconet 30. The fifth BT modules ⑤ are attached, respectively, to the occupants' helmets on the second vehicle B.

[047] In this second piconet, the fourth BT module ④ operates as a master, and the second and fifth BT modules ② and ⑤ operate as slaves. The transmission electricity selected therein is high powered electricity of level 1. Note herein that, utilizing an output control function of the fifth BT modules ⑤, the transmission output is limited to be about class 2, achieving efficient power conservation.

[048] As such, according to the present embodiment, without adopting a scatternet, the relay devices 4a and 4b to be mounted on each first vehicle A are made operate as masters with respect to the respective portable wireless terminals 3, attached to the occupants on the corresponding vehicle. Thanks thereto, while minimizing the electricity consumption of the portable wireless terminals 3, the occupants can enjoy conversation whether they are on the same vehicle or on separate vehicles.

#### Second Embodiment

[049] FIG. 4 is a diagram schematically showing the structure of a second embodiment of the wireless network system to which the present invention is applied. Herein, not only the relay device 4a mounted on the first vehicle A, the relay device 4b mounted on the second vehicle B is also including two BT modules ④ and ⑥.

[050] In the present embodiment, the first BT module ① incorporated in the relay device

4a mounted on the first vehicle A, and the third BT modules ③ of the portable wireless terminals 3ad and 3ap each attached to the occupants' helmets on the first vehicle A structure a first Piconet 22. (The first Piconet 22 is the same as the first Piconet 20 in the first embodiment shown in Figure 3.) In this first Piconet 22, the first BT module ① operates as a master, and the two third BT modules ③ operate as slaves. The transmission electricity selected therein is low power electricity of level 3.

[051] In the present embodiment, the second BT module ② incorporated in the relay device 4a mounted on the first vehicle A, and the fourth BT module ④ incorporated in the wireless terminal 4b of the second vehicle B structure a third Piconet 32. In this third Piconet 32, the fourth BT module ④ operates as a master, and the second BT module operates as a slave. The transmission electricity selected therein is high powered electricity of level 1.

[052] Further, in the present embodiment, the sixth BT module ⑥ incorporated in the relay device 4b mounted on the second vehicle B, and the fifth BT modules ⑤ of the portable wireless terminals 3bd and 3bp each attached to the occupants' helmets on the second vehicle B structure a fourth Piconet 42. In this fourth Piconet 42, the sixth BT module ⑥ operates as a master, and the fifth BT modules ⑤ operate as slaves. The transmission electricity selected therein is low powered electricity of level 3.

[053] As such, according to the present embodiment, without adopting a scatternet, the relay devices 4a and 4b, to be mounted on each first vehicle, are made operate as a master with respect to the portable wireless terminals 3 attached to the occupants on the corresponding vehicle. Thanks thereto, while minimizing the electricity consumption of the portable wireless terminals 3, the occupants can enjoy conversation, no matter whether they are on the same vehicle or not.

[054] Further, according to the present embodiment, the portable wireless terminals 3bd and 3bp of the second vehicle B can select the transmission electricity of class 3.

Therefore, the electricity consumption thereof can be minimized to a greater degree, and battery power of the portable helmet-mounted terminals can be conserved.

### Third Embodiment

[055] In the above embodiments, exemplified is a case where the portable terminals 3 are intercom handsets, and an SCO link of a circuit switching type (mainly for audio signal) is established between the terminals. The present invention is not restricted to the communications systems of the first two embodiments. Not only the vehicle occupants' conversation, but also information on the vehicle condition can be simultaneously exchanged, as shown in FIG. 5, together with or instead of the portable terminals 3. Data processing devices 6a and 6b can be provided for detecting the vehicle running condition, and/or to establish an ACL link. Still further, if the occupants are carrying mobile phones 7a and 7b, incoming and outgoing calls can be made via the relay devices 4a and 4b.

[056] According to an embodiment of the present invention, the following effects can be successfully achieved.

[057] Without adopting a scatternet, a relay device mounted on each vehicle can operate as a master with respect to a portable wireless terminal attached to the occupant on the vehicle. Accordingly, while minimizing the electricity consumption of the portable wireless terminal, the occupants can enjoy conversation no matter if they are on the same vehicle or not.

[058] A relay device is provided with two BT modules. One of them structures a first piconet with another relay device, and the other structures a second piconet with a portable terminal. Therefore, the relay device applies the transmission electricity level of level 1 to the first piconet, and level 2 or 3 can be applied to the second piconet. This successfully allows the first piconet to be wider, and the battery life of the battery in the portable terminal to be extended.

[059] Although the invention has been described herein with respect to a limited number of presently preferred embodiments, the foregoing description is intended to be illustrative, and not restrictive. Those skilled in the art will realize that many modifications of the preferred embodiment could be made which would be operable. All such modifications, which are within the scope of the claims, are intended to be with the scope and spirit of the present invention.